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SOVIET SCIENCE AND TECHNOLOGY

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CENTRAL INTELLIGENCE AGENCY

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APPENDIXES

I. NATIONAL POLICY AND GOALS RELATED TO SCIENCE AND TECHNOLOGY

A. Soviet Domestic Policy

The aim and long-term goals of Soviet scientific effort have been succintly summarized by Academician Igor Kurchatov in his address to the XXI Party Congress: "The scientists of our great motherland will, together with their party, with the entire Soviet people, labor unceasingly to make man the true master of nature in communist society." This has been further elaborated by Ye. K. Fedorov, corresponding-member of the Academy of Sciences, who described as the ultimate two-fold purpose of studies concerning the Earth -- geology, geography, geophysics, geochemistry, geodesy, etc. -- the providing of society with the best means possible to utilize the favorable and useful characteristics of nature, and at the same time to search out means of defense against harmful and unfavorable elemental phenomena. These goals are to be achieved through research in the resolution of three tasks: (1) observation, description and analysis of natural phenomena, their genesis and interrelationship; (2) the forecasting of the development of phenomena in a time sequence; and (3) the study of the possibilities and means of exerting active influence on geophysical phenomena for the purpose of controlling their development to serve the needs of humanity. In the Soviet view, although technological progress reduces man's dependence on natural conditions, this progress also requires increasing consideration

of the most detailed characteristics of natural processes. One implication of these objectives is that given approximately equal technological development of weapons, dominance may come to the nation that is superior in the forecasting and control of natural environmental conditions. Control of nature is not limited to the physical environment. The recent renewed support of Lysenko represents a policy of continued effort to develop control over biological processes, initially to increase agricultural productivity. Efforts to achieve these broad goals began early in Soviet history in support of the post-revolution reconstruction and the planned industrialization and of the development of the planned socialist economy. This early start, in turn, laid the foundations for the establishment of the present vast array of geographic, geodetic, geophysical, and geologic research organizations within the Academy of Sciences and within the governmental departments. In the 1930's, research expanded into the Arctic Basin. Following World War II, Soviet interest beyond the USSR and the Arctic Basin began to emerge -- for example, in early plans (1946) to undertake studies in Antarctica. By the early 1950's, the Soviets claimed to have elevated the study of the Earth to a still higher level in the form of "conjoint research in higher geodesy, geophysics, and geology." Soviet expansion into active world-wide research culminated in 1954 with the announcement of an elaborate Soviet program of participation in the IGY (1957-58) and the joining of the International Union of Geodesy and Geophysics. With the ending of the IGY, the Soviets made vigorous efforts to continue the international world-wide observation

of geophysical phenomena. The Soviets are continuing a large program as a part of the world-wide International Geophysical Cooperation 1959. There are unmistakable indications of Soviet intentions to extend their world-wide pursuit of observational data into the indefinite future.

B. Soviet Foreign Policy

Just as Soviet science has been used as a tool of Soviet policy, so Soviet diplomacy has been used to aid Soviet science in the collection of world-wide data for the continuing studies of the Earth as a whole. In 1950, a Soviet memorandum asserting Soviet rights in any international resolution of Antarctic sovereignty stated as one of its justifications that "this continent and the adjacent islands are a convenient base for most important meteorological observations which are also of significance to the Northern Hemisphere." A goal of Soviet diplomacy today is to secure freedom of research anywhere in Antarctica regardless of existing claims and, at the same time, to exploit Soviet scientific successes and continued presence in Antarctica for the purpose of increasing Soviet prestige and influence in the Southern Hemisphere.

Soviet foreign aid is being used not only to advance Soviet political penetration but also to extend Soviet acquisition of foreign geodetic and gravimetric data which would contribute to the establishment of a Soviet world geodetic datum. This, in turn, would improve Soviet target-location capabilities for possible missile operations. Various types of scientific programs -- geophysical, geologic, topographic mapping -- directed by the USSR or Bloc countries are underway or planned

in India, Afghanistan, Syria, and Egypt, possibly in Ceylon and Bolivia, and most recently Iraq. Furthermore, the Soviets have been energetic in the development of a UNESCO program for the compilation of a regional geologic map for Asia and the Far East.

Other Soviet efforts to widen international scientific relationships are evidenced by their joining of international scientific organizations, such as the IUGG, and attempting to stimulate further activities of organizations already joined (e.g., IGY extension into the International Geophysical Cooperation 1959; Special Committee for Antarctic Research /SCAR/. U.S. scientists have expressed some fear that through these efforts the Soviets may gain control of certain organizations; for example, that they may gain control of the International Union of Geodesy and Geophysics at the 1960 meetings. Another recent tactic has been the incorporation of Soviet scientists into Soviet cultural organizations. In 1959 the Soviets organized a Soviet-Latin American association of friendship and cultural ecoperation. Two of the four vice-presidents are prominent Soviet geographers, one of whom is Director of the Institute of Geography in the new Siberian Department in the Academy of Sciences, USSR, and the other Chairman of the Interdepartmental Antarctic Commission under the Praesidium of the Academy of Sciences, USSR. This may be the beginning of a stepped-up effort to (1) increase the flow of scientific data on Earth studies from Latin-American countries and (2) eventually develop Soviet foreign-aid programs in the Western Hemisphere.

Soviet geographic research on foreign countries is directed towards basic studies of various countries of the world. Such studies are believed to be basic in support of the development and implementation of foreign policy. Emphasis on the study of foreign areas is a characteristic of all leading Soviet universities and research institutes. Of particular note is the growing volume of publications on Southeast Asia, the Near East, and Africa.

II. SOVIET SCIENTIFIC AND TECHNOLOGICAL RESOURCES

A. Native Soviet Resources

1. Basic responsibility for the surveying and mapping of the USSR is vested in the Chief Administration of Geodesy and Cartography (GUGK) attached to the Ministry of the Interior. GUGK works in close concert with the Military Topographic Administration (VTU) of the Army General Staff. These two, together with the Soviet Navy, are authorized to undertake first-order surveying. It is believed that top-level coordination of policy occurs at the ministerial level in a group consisting of both civilian and military planners.

GUGK is a vertically-integrated organization encompassing all functions (except education) from field operations to map publication and includes a Central Scientific Research Institute of Geodesy, Photogrammetry and Cartography. The Military Topographic Administration has a parallel, though smaller organization, including a faculty for advanced geodesy at the Military Engineering Academy im. Kuybysheva (VIA) and a scientific research institute. Soviet research in these fields is believed to be first-class, taking full advantage of the results of

western research and development but at the same time developing its own line of research techniques and instrumentation. Instrument design in photogrammetry and map compilation was simplified to facilitate the development and implementation of the mass program that resulted in the mapping of the entire country at 1:100,000 within the space of 4 decades. Both western- and Soviet-produced electronic and light-interference instruments (geodimeter) are being studied intensively, and indications are that these instruments may replace invar tapes in establishing base nets and lines. Like the US, the Soviet Union is active in the development of instruments for gravity measurement on surface ships in order to speed up the mapping of the gravity field of the Earth. Once these are developed, airborne instruments become feasible. We believe that the Soviets may have started surface-ship observations on an experimental basis as early as 1953. Soviet land gravimeters have not been as accurate as those of the US, but evidence points to Soviet efforts to improve their gravimeters for the next phase of detailed gravity surveys, which would require higher degrees of accuracy. Repeated efforts are being made by the Bloc countries to secure US gravimeters. It is also known that the Soviets have a program for the utilization of Earth satellites as vehicles for establishing intercontinental ties, but no details are available on the nature and organization of the program. Advanced computers are being utilized by the Soviets in geodetic work. One of these, the SESM, is alleged to have been designed to solve linear algebraic equations with up to 400 unknowns, to be capable of doing in 8 hours what would require 20 people working with ordinary machines a full month.

2. Manpower

Conservative estimates have placed the number of personnel engaged in geodetic research at upwards of 6,000 engineers and 10,000 technicians who are trained in geodesy, photogrammetry, and cartography. Recently the head of GUGK admitted that the Soviets had established over 300,000 geodetic control positions in the USSR during the past 40 years, whereas a maximum of about 1,000 per year were established in the U.S. There is some evidence that the Soviets have over 200 field mapping parties in operation and 85 more engaged in gravimetric surveying.

3. Scientific Education and Training

Training of engineers in geodesy is on a very high level in both theoretical and practical aspects, and Soviet instruction and facilities compare very favorably with the best in Western Europe. Advanced training leading to doctorates is provided in 2 major civil, and 1 military institute. In addition, a number of other institutions provide lower-level technical training in surveying and mapping and in geodesy. These include topographic technicums (9), aerial photography schools, agricultural technicums of land utilization, hydrometeorological technicums, and mining technicums. The civil institutes devote one-third of a 5-year course to higher geodesy. Engineering degrees are being conferred at the rate of about 400 per year. Graduate training is given not only at the 2 major civil institutes but also at several scientific research institutions. Between 1937 and 1955, some 42 Doctorates of Technical Sciences in Geodesy were granted. In 1955 alone, at least

40 candidate-degree (i.e, master's) dissertations and one doctorate were presented.

B. Exploitation of Non-Soviet Resources

As a matter of explicit policy the USSR has striven for years to become wholly independent of foreign sources for technical personnel and instruments in geodesy, gravimetry, and photogrammetry. As a result the Soviets have a well-established geodetic and photogrammetric instrument industry capable of meeting any basic requirements in geodesy and photogrammetry, but not yet those in gravimetry. The Soviets, however, scrutinize closely western developments in techniques and methods as well as in instrumentation. In many instances, they have been adapted, often with simplification, to meet the needs of the mass Soviet program of surveying and mapping the country (at 1:100,000) in the shortest possible time (completed in 40 years). In this program there has been no need for elaborate, complex, and time-consuming photogrammetric plotters. The Soviets, however, have pioneered in the extensive use of super-wide-angle lenses to provide the widest horizon-to-horizon coverage for use in their aerial mapping program. For gravimeters the Soviets have been more dependent on Western developments. Western instruments are being copied, and the European Norgaard gravimeters have been purchased in quantity for field use. Persistent efforts are still being made, even covertly, to secure US gravimeters in order to develop more accurate and consistent instruments to meet the requirements of the new phase of Soviet work. The Soviets, however, have secured a maximum gain from European Bloc mapping organizations, personnel, and

facilities by requiring that the Bloc countries convert their geodetic datums and mapping systems to those of the Soviets. These requirements have not been imposed on the Chinese Communists; nevertheless evidence suggests that the Chinese may be following the Soviet scheme in the mapping of China.

III. STRATEGIC ASPECTS OF SCIENTIFIC RESEARCH -- LONG-RANGE OUTLOOK

A. Physical Sciences

The Soviet Union, at an early date recognized the need (a) to explore, survey and inventory its natural resources, (b) to initiate land-use planning and development programs, and (c) to cope with the problems of a harsh physical environment. This gave the Soviets an early start in undertaking a number of basic research and survey programs for Earth studies. Topographic mapping of the entire USSR was begun in 1919; geomagnetic and gravity surveys of the USSR were launched in the early 1930's; and the polar research was initiated with the launching of the first polar drift station in 1937. This work provided a solid foundation for the postwar extension of research to the Earth as a whole. The early start, combined with the establishment of a vast array of research organizations to plan long-range integrated programs and to process the resulting observational data into finished studies, has placed the USSR in an advantageous position compared with that of the US in the study of the Earth.

At present the USSR is probably ahead of the US in attaining a world geodetic datum that will improve target-location capabilities for long-range missiles. This advantage is due largely to the head

start of the Soviet world-wide oceanographic program and to the policy of withholding Soviet topographic maps and gravity data, whereas those of Western nations are freely available. Although geodesy will ultimately benefit from future Earth-satellite programs, significant improvements in international positioning, in the value of the Earth's flattening, and in the knowledge of Earth's gravity field will materialize slowly over the next decade. The reason is not only the length of time required to develop new methods and techniques, but also the complications involved in securing world-wide coverage of observations. If the Soviets succeed in (1) developing and implementing an extensive air and sea gravity program, and (2) securing widespread coverage of satellite observations, they may make significant improvement in the precision of satellite tracking and orbit prediction. This could also improve their capabilities for (1) more accurate calculation of range and azimuth between launch points and targets, and (2) positioning photographs from future satellite reconnaissance photography.

IV. SCIENCE AND TECHNOLOGY SUPPORTING THE SOVIET ECONOMY AND INDUSTRIAL DEVELOPMENT

The early Soviet implementation of programs for topographic mapping, resource exploration, and the study of the Earth has been widely acclaimed in Soviet literature as having laid the basis necessary for Soviet successes in the transformation of an early agrarian economy into a modern industrial economy. In addition, geographic studies have provided basic information concerning the problem of delineating regions suitable both for planning and administering the economic development

of the USSR. The nature of economic regions has varied widely from time to time. The dozen traditional economic-geographic regions that formed the planning framework have been found to be inadequate. A Commission for Delimiting the Basic Economic Region Network of the USSR was established and held a number of conferences in 1956-57. Basic changes recommended by the Commission, and by others as well, range from proposals to form as many as 24 economic regions to as few as 4.

The Seven-Year Plan incorporates the extension of geodetic, gravimetric, and topographic surveying and mapping and of resource exploration, particularly in the Arctic and sub-Arctic areas of Siberia and the Far East. With the 1:100,000 topographic map series completed, the Soviets are now embarking on an extensive program to map all significant areas at 1:25,000. Geodetic-control surveys are to be improved and extended. The most significant extensions are planned for vast areas of Siberia and the Far East -- to extend triangulation to the Arctic coast and to replace the astronomic control used initially in the compilation of the 1:100,000 topographic maps of the area north of the Trans-Siberian Railroad zone. Hydrographic charting and ice forecasting, together with the use of icebreakers and freighters, are expected to extend the navigation season and freight capacity of the Northern Sea Route, the principal supply line in the Soviet Arctic.

Over the long term, Earth studies and regional geographic research are likely, slowly but gradually, to improve Soviet ability in correlated

forecasting of frost, drouth, and the availability of underground water supplies. This research is directed toward the improvement of the agricultural capabilities of marginal lands.

V. MILITARY RESEARCH AND DEVELOPMENT CAPABILITIES

A. Key Supporting Fields: Mapping

Soviet geodesists are among the world's foremost in both practical and theoretical geodesy. The ambitious nature of their programs and the heavy investments in their implementation has also resulted in the development of a vast, sophisticated mapping organization that is highly integrated in purpose and programs and has objectives that meet not only the domestic needs of the economy but also are able to support Soviet world-wide military interests. The entire USSR has been mapped at 1:100,000, which represents a major achievement not only for economic development but also in support of Soviet defense capabilities. Moreover, when completed during the next decade, the expansion of Soviet first-order control into all of Siberia and the Far East will increase military flexibility in the future locating of guided-missile sites. Early gravity programs and associated research have been of interest not only to resource exploration and to the solution of geodetic problems unique to the extensive meridional extent of the USSR, but have also given the Soviets an early lead (fostered to a great extent by the denial of gravity data by the military to the West) in the eventual establishment of a world geodetic datum. This will lead to increased accuracy in intercontinental positioning. Moreover, it will strengthen Soviet studies on the external

gravity field of the Earth. Together with continued refinements in the studies of the perturbations of orbits of satellites, the Soviets may make significant advances both in the precision of satellite tracking and the prediction of orbits. This could improve their capabilities for (1) accurate calculation of range and azimuth between launch sites and targets, and (2) positioning photographs from future satellite reconnaissance, if and when undertaken.

Military interests have been furthered by the Soviet surveying and mapping programs in peripheral non-Soviet areas -- up to now in Syria, Egypt, Afghanistan, India, possibly Ceylon and Bolivia, and most recently in Iraq -- and by the active collection of foreign topographic maps. The latter gives the Soviets a clear target-positioning advantage over the US since they have effectively denied Soviet maps to the US.

B. Key Supporting Fields: Polar Research

Long-continued Soviet research in the Arctic, 4 years of extended operations in the Antarctic, and more than a decade of scientific observations by the Soviet Antarctic whaling fleet, have given the Soviets an outstanding capability for air, sea, and land operations in polar areas. This has particular strategic significance in the Arctic. The large mass of data (much of it withheld from the US), the years of practical operational experience, and a sizeable permanent population give the Soviet Union a uniquely advantageous position in planning and conducting military operations involving under-ice navigation, aircraft, guided-missiles, as well as in related operations such as weather forecasting and control

The indicated high level of continued polar research in the Arctic and Antarctic points not only to further scientific progress but also to an increase in Soviet preeminence in polar capabilities.

APPENDIX A

Soviet Goals and Achievements in Geodesy, Gravimetry, and Mapping

A. Introduction

Soviet policy has always recognized that a strong national geodetic and cartographic system is essential for planning the agricultural and industrial development of the nation. The production of maps of the USSR, consequently, was expanded after the readjustment of horizontal control in 1942-46. The topographic series at 1:100,000, containing approximately 20,000 sheets, received the most concentrated effort and is now completed for the entire country. Geodesy, however, has taken on importance beyond merely serving as a basis for mapping control. The development of long-range-weapon systems and artificial earth satellites has extended the area of practical geodetic interest to include the surface of the whole Earth.

Soviet theoretical geodesy reveals a keen awareness of this "whole Earth" concept of modern geodesy. For very practical reasons of military urgency the geodesist today, more than ever, seeks a better determination of the figure of the Earth. Ultimately, after intercontinental ties are made across the oceans, a single world geodetic datum will be a possibility. By continuing the present policy of collecting world-wide data while withholding its own geodetic data from other nations, the Soviet Union hopes eventually to win scientific recognition as the first nation to establish a world geodetic datum.

Early interest in gravimetry for geodetic purposes has given the Soviets an advantageous foundation for the study of the external gravity field which is likely to improve capabilities not only for target location but also for positioning photographs from reconnaissance satellites, if and when such are launched.

B. Soviet Organizational Facilities and Resources

Basic surveying and mapping of the country as a whole is centralized in the Chief Administration of Geodesy and Cartography (GUGK), which is now attached to the Ministry of the Interior. GUGK works in close concert with the Military Topographic Administration (VTU) of the Army General Staff. Little is known of the nature of this collaboration and its relation to policy formation.

Relations between GUGK and the services of the Ministry of Defense are known to be regulated by a special statute, the text of which has not yet been obtained. It is also known that basic geodetic surveying of the first three orders is conducted by GUGK, the Army, and the Navy. Of the military services, the Army appears dominant since it is the only service that has been identified as having the right to serve as co-author with GUGK in the issuance of basic geodetic and cartographic specifications and regulations. It is believed that top-level coordination of policy occurs at the ministerial level in a group consisting of both civilian and military planners.

GUGK is an integrated organization that, in addition to the conventional technical and administrative units, includes two policy bodies -- a Collegium for broad program planning and research and another body for the coordination of interagency mapping projects and activities. The second group includes central archives for the custody of all data, a central publishing organization for geodetic and cartographic literature, a central research institute, a factory for the production of geodetic and mapping instruments, 12 photogrammetric and geodetic establishments, and 12 cartographic plants. The Military Topographic Administration includes a Military Topographic Service; a faculty for advanced geodesy at the Military-Engineering Academy im. Kuybysheva (VIA); a scientific

research institute; and, according to a prewar source, 12 topographic units, 7 geodetic units, 3 aerial photographic units, 12 geodetic and cartographic units, and a field training and testing camp.

Training in surveying and mapping, which dates back to 1779, has been particularly emphasized under the Soviet regime. Estimated conservatively, the Soviet Union currently has some 6,000 engineers and 10,000 technicians trained in geodesy and cartography. The ranks of GUGK (including its predecessor agencies) have increased from 469 in 1924 to 5,058 in 1940 and to an estimated 9,000 in 1953.

Training of engineers in geodesy is on a very high level, in both theoretical and practical aspects; and Soviet instruction and facilities compare very favorably with the best in Western Europe. Advanced scientific education and technical training is provided by the largest system of special educational institutions in the world. Civil and military personnel have independent training facilities. At the university level, advanced civilian training in which one-third of a 5-year course is devoted to higher geodesy is given in 2 institutes, which together are conferring engineering degrees at the rate of about 400 per year. Graduate training is given not only at these two institutes but also at several scientific research institutions. Between 1937 and 1955, some 42 Doctorates of Technical Sciences in geodesy were granted. In 1955 alone, no fewer than 40 candidate's (i.e., master's) dissertations and one doctorate were presented by higher institutions of learning. With geodetic training of this depth, it can readily be seen that the Soviets already have a formidable reservoir of geodesists available to staff operational-missile units.

C. Significant Soviet Accomplishments, Trends and Objectives in Geodesy, Gravimetry, and Mapping

1. First-Order Horizontal Control

Soviet geodetic control has had the great advantage of a recent readjustment (1942-46), which unified into a single system all earlier first-order triangulations within the country. The new Krasovskiy ellipsoid was adopted in 1946, and new geodetic coordinates were assigned to the initial point at Pulkovo Observatory. From analysis of gravity observations over the entire area of the USSR, the Soviets uniquely were able to construct geoidal profiles along arcs of triangulation, making possible the reduction of angle and distance measurements from the Earth's surface directly to the ellipsoid. The Soviet claim that this projection method is superior to other reduction methods used elsewhere in the world is probably correct. However, the relative strengths of different datums and continental nets, or the fitness of any one to serve as a world datum, cannot really be determined before methods become available for bridging the oceans geodetically.

At least two-thirds the area of the USSR is now covered by first-order horizontal control. A new field survey along the principal rivers flowing northward into the Arctic Ocean is operating continuously. Despite Soviet reluctance to reveal first-order work east of Magadan, there is reason to believe that Soviet control now extends to the Bering Strait. Estimates given privately in conversation between US and Soviet geodesists indicate that the USSR will be completely covered by first-order horizontal control within less than 10 years.

The integration of the geodetic systems of the European Sovbloc nations with that of the USSR has been in progress since 1952. The separate national geodetic datums have been abandoned in favor of the

Pulkovo 1942 Datum of the USSR, and all the necessary additional field work and the readjustment of control to the Soviet system have been completed. Mapping based on the new control is well under way in all the Satellite countries. The topographic series for East Germany at 1:25,000 is already completed (1,536 sheets). It now seems likely that the mapping program initially set up at Sofia in 1952 will be essentially completed within the next few years.

Geodetic information regarding Communist China is scant. China has purchased geodetic equipment from the West and from East Germany, and undoubtedly also from the USSR. The Soviets have sent specialists to China to formulate geodetic programs and to direct some of the field work. Thus far, no information is available regarding the progress of field work by the Chinese. Ties across the border to the Soviet net have probably been made, although there is no indication as yet that the Soviet datum has been adopted by China. How well the Chinese data fit the Soviet datum will be a matter of great interest in the years ahead.

2. Possible Bering Strait Connection

Soviet and US control points are closest to each other at the Bering Strait. Since Alaskan geodetic data have been available to the Soviets in the past and since an accurate connection across the Strait would clearly be advantageous to them, they have probably already made a preliminary connection by covert means or by aerial photography. Since only very poor maps of the Chukotsk area are available in the US and since the Soviets withhold information on a possible connection from the Strait to the main net in the USSR, the US would have little to gain by simply making the connection across the Strait. The Soviets have already dropped hints that, at the forthcoming Helsinki IUGG meeting in 1960, they will propose a joint operation with the US to make the

tie across Bering Strait. Preparation to meet this challenge should not be neglected. US interests would be served equally with those of the Soviets only if agreement could be reached to exchange geodetic data and large-scale maps of areas within a radius of several hundred miles of the Strait.

3. Gravity Observations

Gravity values from all over the Earth's surface provide a unique method of determining the shape of the Earth. The Soviets have found the gravity approach to geodesy most helpful in setting up their datum and in reducing measured angles and distances to the ellipsoid. To obtain a better understanding of the relationship between the Earth's surface, the geoid, and ellipsoid, it has long been recognized that gravity observations from representative areas all over the Earth are needed. Because intercontinental positioning will be improved as these gravity observations are made, the data assume the significance of military information. The overlapping interest in gravity by scientists and military planners has led to conflict of opinion over the release of data in the US and to strict withholding of the data in the USSR. There is little prospect for relaxation of the Soviet policy with respect to gravity data in the near future.

The urgency for obtaining gravity data from all over the Earth has given precision instrument builders an incentive to create apparatus for measuring gravity on surface ships in moderately calm seas. Heretofore gravity at sea has been measured by pendulum apparatus (Vening Meinesz type) in a submerged submarine. This method has been slow and costly and is not suited to a worldwide oceanic gravity program. Promising results from surface vessels have been achieved by the US within the past year, using stabilized platforms, gravimeters similar to portable

land types, and electronic circuitry for continuous recording. The Soviets are definitely working along the same lines but are very guarded in what they reveal concerning their progress. They have experimented with ship-borne apparatus with apparent success. In this field they may even be ahead of the US. If gravity can be measured reliably on surface vessels, the transition to airborne measurement presents no serious technical difficulty. The US is already testing airborne gravimeters, and the Soviet Union is possibly doing the same. Within the next 5 years the Soviet Union, working independently on the sea and in the air, should acquire enough new gravity data to justify their recalculation by them of geoidal heights and undulations over the entire Earth's surface. In the conquest of science as a pathway toward world power, there is no doubt that the Soviets aim to be foremost among nations in the study of the structure of the Earth. Gravity provides a key method of approach to this study.

4. Soviet IGY Geodetic Work in Antarctica

Astronomic observations have in the past provided the basic control for whatever mapping has been done of Antarctica. Aside from the usual triangulation between astro points, geodetic interest in Antarctica centers upon gravity determinations made in the area. It is believed that during the IGY the Soviets made extensive gravity determinations at Mirny, at various points on their inland excursions to set up meteorological stations, and in the coastal waters traversed by their oceanographic vessels. Because such gravity observations were outside the scope of IGY planning, the Soviets were not obligated to disclose these gravity data. Prior to the commencement of the IGY the Soviets seemed anxious to compare their gravimeter readings with those of the US at Mirny. This would be desirable for calibrating the instruments,

since some drift by a gravimeter is to be expected. When a US Worden gravimeter was brought ashore at Mirny, however, the Soviets were unwilling to put their own gravimeter to any sort of test. Since gravity values have to be reduced to sea level to be of comparative value, inland Antarctic observations suffer from uncertainty regarding station elevation. The Soviets probably made many inland observations, using the best barometric means available to determine elevations. Such a gravity program would, in the Soviet manner of thinking, be a necessary preliminary for control of the accuracy needed for an Earth satellite observation station. The Soviets were probably more interested in making gravity observations on their sea and land expeditions during the IGY than is indicated in the printed record of their achievements. With the establishment of additional stations for the observation of Earth satellites, the Soviets may be expected to stress the making of gravity observations in Antarctica even more strongly in the future.

5. Geodesy from Earth Satellites

Geodesy will ultimately benefit greatly from the study of Earth satellites. Methods will be found in the US and the USSR to improve intercontinental positioning, to get a better value of the Earth's flattening, and to determine the Earth's gravity anomalies. For geodetic purposes, a number of Earth satellites at different altitudes above the Earth and different eccentricity and inclination of orbit are needed. More refined methods are also required for determining the position of the satellite and the time of its observation. Also needed are accurately positioned stations well distributed over the Earth. Although no admission has come from the Soviets, it is evident that their satellite program suffers from dependence upon other parts of the world to contribute observational data. The Soviet Union is just not big enough so that

observations from that country alone are sufficient for the study of precise orbits. This is why the Soviets will undoubtedly set up stations in Antarctica, and possibly in other areas in the Southern Hemisphere, through diplomatic and international scientific arrangements.

Benefits to geodesy from Earth satellites are not likely to be forthcoming for some time either in the US or USSR. These will first require satellites several thousand miles from the Earth; and only through the analysis of data from a number of such orbits can consistent final results be obtained. The present outlook is for continued aloofness on the part of the Soviets in sharing their raw observational data. Because of the frictions developed by a dual satellite program, of the US and USSR, geodetic advance may be slower than otherwide; but the competition will ultimately lead to geodetic results of great significance to mapping.

The Soviets may also advance in their study of the external gravity field of the Earth through air-borne gravity surveys and artificial satellites. Coupled with their known studies of perturbations of satellite orbits, the Soviets may make significant advances both in improving the precision of satellite tracking and orbit prediction. This could improve their capabilities for (1) more accurate calculation of range and azimuth between launch points and targets, and (2) positioning photographs from future satellite reconnaissance photography.

APPENDIX B

The Role of Geography in Soviet Science and Technology

A. Soviet Foreign Policy (Section I-B)

Soviet geographic research on foreign countries is directed towards basic studies of the various countries of the world in which all phases of geography are included regardless of immediate strategic value. Such studies are producing an increasingly important basis for the development and implementation of foreign policy.

The geographic sections of all leading Soviet universities and research institutes emphasize the study of foreign countries. In the Geographic Faculty of Moscow University, for example, 3 of the 14 departments are devoted to teaching the geography of other countries, a fourth to polar geography, and a fifth to oceanography. In the Institute of Geography of the Academy of Sciences, 2 of the 10 sections are concerned exclusively with foreign countries, preparing both country monographs and special studies. Two other institutes in the Academy of Sciences are engaged in extensive research on areas outside the Soviet Union. The Institute of Oceanography (together with related organizations) conducts research on all the oceans of the world and in at least 17 foreign countries. The Institute of Oriental Studies includes among its other work important geographical research.

Soviet publications reflect the increasing world-wide interests of the Soviet Union. Of particular significance is the growing volume of publications on Southeast Asia, the Near East, and Africa. Publications range from short, generalized, popular descriptions of an entire country to detailed studies of specific branches of the economy and exhaustive studies of the peoples. All are of basic value in planning economic, cultural, and political penetration. In 1958, more than one-third

of the space in the two leading Soviet geographic journals was devoted to countries other than the USSR; and a single monthly issue of Referativnyy Zhurnal, Geografiya (Feb 59) included at least 67 references to books and articles on foreign countries written by Soviet geographers.

Soviet geographers have also greatly increased their participation in international organizations and conferences. In one year alone, they were represented at the Ninth Pacific Science Congress, the Regional Conference on the Geography of Asia, and the Second Meeting of Economic Geographers of Eastern Europe, and at major conferences on national atlases, ornithology, the climate of arid zones, Afro-Asian geography, Arctic sea ice, and geodesy and geophysics. Some 300 Soviet geographers plan to attend the Nineteenth Congress of the International Geographic Union in 1960. These activities are evidence of a concerted effort to overcome a significant weakness on the part of Soviet geographers -- inadequate first-hand knowledge of foreign countries.

APPENDIX B

B. Soviet Scientific and Technological Resources (Section II-A)

1. Native Soviet Resources: Scientific Education and Training (II-A-3)

In the field of geography, university training emphasizes basic topical disciplines (soils, cartography, economic geography) and their practical application to regional research, including an excellent summer field-work program in which students participate in research expeditions. The result is a constant flow of well-trained geographers into schools, research institutions, and government agencies, thus providing a reservoir of workers who have detailed regional knowledge and are trained in the Soviet concepts of regional economic development. To a large extent the geography curricula of the universities are determined by the state, and research is performed on contract for various government agencies.

The geographic research effort is impressive both in its material aspects -- large staffs, budgets, and facilities -- and in the scope and nature of the program. An analysis of contemporary Soviet publications and maps, and evaluations by competent western geographers who have visited the country and its research centers in recent years have demonstrated that geographic training and research in the Soviet Union today are outstanding in quantity and quality as well as in scope of interest.

2. Exploitation of Non-Soviet Resources (II-B)

Close working relations between Soviet geographers and those of China and the Satellite countries have resulted in a large number of joint expeditions and jointly prepared monographs. Geographic and cartographic work in all bloc countries, especially Communist China, reflect Soviet influence.

An important aspect of the geographic research is the exploitation of non-Soviet source materials through an elaborately organized bibliographical effort. The February 1959 edition of Referativnyy Zhurnal, Geografiya includes more than 1,400 citations dealing wholly and specifically with foreign countries gleaned from more than 600 geographic and nongeographic sources published throughout the world. A large proportion of the citations are accompanied by resumes, and full copies of all the cited material are available to any interested researcher.

APPENDIX B

C. Strategic Aspects of Scientific Research: Physical Sciences (Section III-1)

For the past two decades, an organized scientific Arctic research program has been conducted in which geographic research is coordinated with research in the numerous related fields of physical science. More recently, emphasis has shifted to the strategic aspects of the Arctic. In 1954 the Arctic Program of the Academy of Sciences was greatly expanded. More than 100 polar stations have now been established; numerous exploratory geologic and geodetic field parties are conducting research in the Arctic; some 20 oceanographic research vessels are in operation in late summer; and 2 drifting scientific stations are currently collecting geophysical data. As a result of scientific research, improved topographic, geologic, and geodetic maps of the mainland and islands and hydrographic charts of the Arctic Seas have been produced. An early start in the amassing of scientific data gave the Soviet Union an advantage over all other countries, since collection is necessarily a slow process. Disciplines based on long-term observations -- such as meteorology, ice reconnaissance, and permafrost investigation -- have long been studied by the Soviets; and the vast amount of data that has been collected, processed, and published provides a solid background for current research.

The IGY provided an additional impetus to the collection of data not only on the Soviet Union but also on the rest of the world. Over 100 scientific organizations directed by the Academy of Sciences cooperated in this effort. In the Soviet Arctic, alone, about 60 scientific stations are now operating. The scope of the Arctic research in disciplines such as oceanography, glaciology, geomagnetism, ionospheric physics, and seismology is much more extensive than that of all other coutries bordering the Arctic combined.

During the next 5 to 10 years, scientific advances of significance to Arctic research can be expected. The collection of data will certainly be further automated, and greater amounts and new types of information be anticipated from both drifting and stationary automatic meteorologic stations. Atomic-powered icebreakers that can operate in pack ice will provide opportunities for extending the oceanographic research now performed by drifting stations and high-latitude air expeditions; and atomic submarines sailing under the sea ice will facilitate investigations of marine biology and physical, chemical, and dynamic oceanography, and studies of ocean-bottom topography and composition.

D. Science and Technology Supporting the Soviet Economy and Industrial Development (Section IV)

1. Resource Development (IV-1)

The Soviet Union, more than any other country of the world, has capitalized on the results of geographic research in the development of its internal economy. All of this research is focused on the practical application of geography, chiefly the acceleration of economic development through efficient exploitation of the varied and widespread natural and human resources of the Soviet Union. Research of the Institute of Geography of the Academy of Sciences includes the fields of geomorphology, climatology, hydrology, biogeography, economic geography, cartography, and glaciology. The main effort of this research is concentrated on two problems -- maximum utilization of resources that are of current economic value and means for altering the natural environment to permit utilization of latent resources.

Of particular interest in this connection is the problem of regionalization. Recognizing that the 12 traditional economic-geographic regions which have served as the basis for national planning do not adequately serve current needs and goals, a complete realignment of economic-geographic regions is being studied. A Commission for Delimiting the Basic Economic Region Network of the USSR was active in the 1956-57 period, a number of special conferences have been held, and recommendations for changes are now being considered. These vary from the formation of 24 economic regions with some specialization and exchange of products (as approved by the Commission), to the division of the nation into 4 large regions that would be economically autonomous. A decision on a new alignment of regions may be expected within the next few years.

In the Arctic and Sub-Arctic, continued geologic mapping and field exploration will probably reveal new mineral deposits. Their exploitation will bring more people to the Arctic, and new settlements will be established. In the new settlements, small nuclear powerplants and tidal electric stations will offer new sources of power. Field surveys and construction plans for tidal stations have already been completed for some coastal areas within the European Arctic.

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